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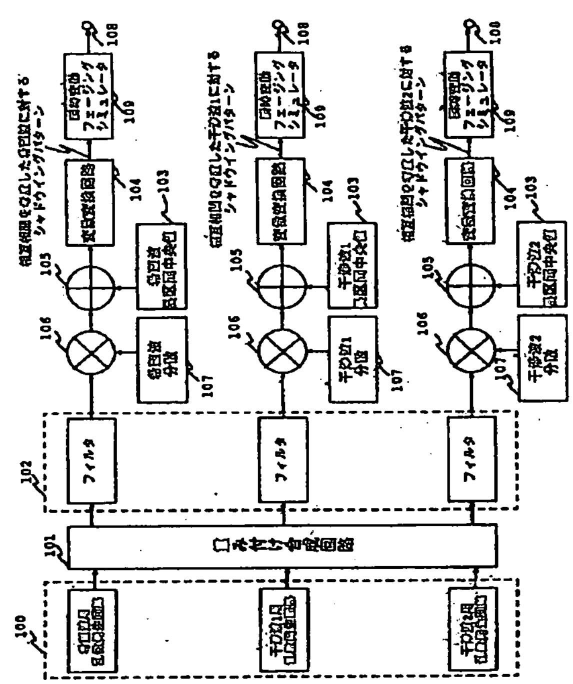
(54)【発明の名称】　フェージングシミュレータ

(57)【要約】

【目的】　本発明では、希望波とＮ波の干渉波に生じるシャドウイングに対して任意の組合せの相互相関を考慮してシミュレートすることができる汎用性の高いフェージングシミュレータを提供する。

【構成】　Ｎ＋１個の乱数発生回路群１００は、希望波とＮ波の干渉波に対するシャドウイングとして、独立な正規乱数を発生する。重みづけ合成回路１０１では、発生された独立な乱数を重みづけ合成し、それぞれの乱数が所望の相互相関を持つＮ＋１個の正規乱数として出力する。重みづけ合成回路１０１からのＮ＋１個の正規乱数はそれぞれフィルタ群１０２によって平滑化され、それぞれの波に対して予め定められた分散及び中央値をそれぞれ乗算及び加算して、変数変換回路群１０４に入力される。それぞれの変数変換回路では、入力された正規乱数を例えば対数正規分布に従う乱数に変換して出力する。



【特許請求の範囲】

【請求項1】希望波とN波の干渉波から成るN＋1波の波を扱うフェージングシミュレータにおいて、

a）それぞれ独立な白色の正規乱数過程を発生するN＋1個（Nは自然数）の乱数発生回路群と、

b）前記N＋1個の正規乱数発生回路群からの出力を入力し、それぞれの入力信号を重みづけ合成して、N＋1個の相関のある乱数系列群を出力する重みづけ合成回路と、

c）前記重みづけ合成回路から得られるN＋1個の相関のある乱数系列群のそれぞれを入力とするN＋1個の低域フィルタ群と、

d）前記希望波とN波の波に対する短区間中央値変動の分散を記憶するN＋1個の第1の記憶回路群と、

e）前記第1の記憶回路群に記憶された値と前記N＋1個の低域フィルタ群の出力を乗算するN＋1個の乗算器群と、

f）前記希望波とN波の波に対する長区間中央値を記憶するN＋1個の第2の記憶回路群と、

g）前記N＋1個の乗算器群のそれぞれの出力に対して、前記N＋1個の第2の記憶回路群に記憶されている前記希望波とN波の波に対する長区間中央値を加算するN＋1個の加算器群と、

h）前記N＋1個の加算器群の出力に対して変数変換を行なう変数変換回路と、を有することを特徴とするフェージングシミュレータ。

【請求項2】請求項1記載のN＋1個の正規乱数発生回路群において、

a）前記N＋1個の正規乱数発生回路群から発生される独立な白色の正規乱数過程は、それぞれ等しい分散を有する、ことを特徴とする請求項1記載のフェージングシ＊＊ミュレータ。

【請求項3】請求項1記載の重みづけ合成回路において、N＋1個（Nは自然数）の入力信号、R_i，$i=1, 2, \cdots, N+1$に対して、

a）入力信号R_i（$i=1, 2, \cdots, N+1$）に対する第1の重みづけ係数群$a_{i,i}$を記憶する記憶回路群1と、

b）前記第1の重みづけ係数群$a_{i,i}$と前記入力信号R_i（$i=1, 2, \cdots, N+1$）をそれぞれ入力とするN＋1個の第1の乗算回路群$Multi_{i,i}$と、

c）i番目（$i=1, 2, \cdots, N+1$）の入力信号R_iに対するN＋1－i個の第2の重みづけ係数群$a_{i,j}$，（$j=i+1, i+2, \cdots, N+1$）を記憶する第2の記憶回路群と、

d）前記i番目（$i=1, 2, \cdots, N+1$）の入力信号R_iと前記第2の重みづけ係数群$a_{i,j}$，（$j=i+1, i+2, \cdots, N+1$）を入力とする第2の乗算回路群$Multi_{i,j}$と、

e）前記N＋1個の第1の乗算回路群のk番目（$k=2, 3, \cdots, N+1$）の乗算回路（$Multi_{k,k}$）の出力と前記第2の乗算回路群のうち$Multi_{n,k}$，（$n=1, 2, \cdots, k-1$）の出力を入力とするN個の加算器群とを、有することを特徴とする請求項1及び2記載のフェージングシミュレータ。

【請求項4】請求項3記載の第1及び第2の重みづけ係数群、$a_{i,j}$，（$i=1, 2, \cdots, N+1$　$j=i, i+1, \cdots, N+1$）において、重みづけ合成回路出力のうちi番目の出力とj番目の出力との正規化相関係数を$\rho_{i,j}$（$=\rho_{j,i}$），それぞれの自乗平均値を1．0とするとき、

【数1】

$$\text{a)}\ a_{1,1}=1.0, a_{1,j}=\rho_{1,j}, a_{2,2}=\sqrt{1.0-a_{1,2}^2}, (j=2,3,\cdots,N+1)\text{ とし，}$$

$$\text{b)}\ j=3,4,\cdots,N+1\text{ の順で } j \text{ を固定し，} a_{i,j}=\frac{\rho_{i,j}-\sum_{k=1}^{i-1}a_{k,i}a_{k,j}}{a_{i,i}}\text{ に従って，} i=$$

$$2,3,\cdots,j-1\text{ について漸化的に求め，さらに，} a_{j,j} \text{ を } a_{j,j}=\sqrt{1-\sum_{i=1}^{j-1}a_{i,j}^2}$$

$$\text{として求め，漸化的に } a_{i,j}, j=1,2,\cdots,N+1\ \ i=1,2,\cdots,j \text{ を求める}$$

ことを特徴とする請求項1，2及び3記載のフェージングシミュレータ。

【発明の詳細な説明】

【0001】

【産業上の利用分野】本発明は、希望波とN波の干渉波に生じるシャドウイングの相関を考慮した通信路をシミュレートすることができる汎用性の高いフェージングシミュレータに関する。

【0002】

【従来の技術】陸上移動通信における電波伝搬環境を特徴づける要因として、次の3つの現象を挙げることができる。

【0003】1．伝搬距離の差が搬送波波長オーダ程度の波が合成された信号を受信するため、送信局あるいは受信局が搬送波波長オーダ程度移動すると受信レベルが大きく変動する現象（レイリーフェージング）

2．伝搬距離の差が信号帯域幅の逆数オーダ以上の波が合成される場合、ゴーストや符号間干渉による歪が生じる現象（周波数選択性フェージング）

3．　送信局あるいは受信局周囲のビルや樹木によっ

て、信号が遮られることによる受信信号レベルの変動（シャドウイング、短区間中央値変動）
陸上移動通信では、これらの現象が複合して生じるため、非常に複雑な伝搬モデルを考慮する必要がある。このような伝搬環境をシミュレートするために、周波数選択性フェージングとレイリーフェージングを考慮したもの（例えば、辻本一郎、“フェージングシミュレータ”、特願平２－８６３５２）が知られている。一方、シャドウイングの効果も考慮したシミュレータとしては、図２のように、実際に電波を発射する実験を行なって得られたシャドウイングによる受信信号レベル変動のデータを用い、その値を元にレイリーフェージングのシミュレートを行なう構成のものが知られている（金井敏仁、武次將徳、近藤誠司、古谷之綱“ディジタル移動通信用高速ハンドオフ方式実験システム”、電子情報通信学会，無線通信システム研究会技術報告書、ＲＣＳ８９－３７、１９８９年）。

【０００４】

【発明が解決しようとする課題】上述のように、シャドウイングを考慮したフェージングシミュレータとしては、実験に基づいたデータを用いたものしか知られておらず、汎用性が非常に低い。さらに、セルラーシステムにおいては、電波のオーバーリーチ等により、移動局では様々な方向に存在する複数の基地局からの電波を受信してしまう。シャドウイングは、送信点や受信点の周囲のビルや樹木によって生じるものであるから、受信点から見て同じ方向にある基地局からの電波には相関の高いシャドウイングが生じており、異なる方向にある基地局からの電波には相関の低いシャドウイングが生じていると考えられ、このように、汎用性の高いシミュレータを得るためには、シャドウイングの相関も考慮する必要がある。

【０００５】

【課題を解決するための手段】本願の発明である希望波とＮ波の干渉波から成るＮ＋１波の波を扱うフェージングシミュレータにおいて、ａ）それぞれ独立な白色の正規乱数過程を発生するＮ＋１個（Ｎは自然数）の乱数発生回路群と、ｂ）前記Ｎ＋１個の正規乱数発生回路群からの出力を入力し、それぞれの入力信号を重みづけ合成して、Ｎ＋１個の相関のある乱数系列群を出力する重みづけ合成回路と、ｃ）前記重みづけ合成回路から得られるＮ＋１個の相関のある乱数系列群のそれぞれを入力とするＮ＋１個の低域フィルタ群と、ｄ）前記希望波とＮ＊

＊波の波に対する短区間中央値変動の分散を記憶するＮ＋１個の第１の記憶回路群と、ｅ）前記第１の記憶回路群に記憶された値と前記Ｎ＋１個の低域フィルタ群の出力を乗算するＮ＋１個の乗算器群と、ｆ）前記Ｎ＋１個の乗算器群の出力に対して変数変換を行なう変数変換回路と、ｇ）前記希望波とＮ波の波に対する長区間中央値を記憶するＮ＋１個の第２の記憶回路群と、ｈ）前記Ｎ＋１個の変数変換回路群のそれぞれの出力に対して、前記Ｎ＋１個の第２の記憶回路群に記憶されている前記希望波とＮ波の波に対する長区間中央値を加算するＮ＋１個の加算器群とを有している。

【０００６】本願の発明のフェージングシミュレータの正規乱数発生回路群において、ａ）前記Ｎ＋１個の正規乱数発生回路群から発生される独立な白色の正規乱数過程は、それぞれ等しい分散を有するものを用いている。

【０００７】本願の発明のフェージングシミュレータの重み付け合成回路において、Ｎ＋１個（Ｎは自然数）の入力信号，R_i，ｉ＝１，２，・・・，Ｎ＋１に対して、ａ）入力信号R_i，（ｉ＝１，２，・・・，Ｎ＋１）に対する第１の重みづけ係数群$a_{1,i}$を記憶する記憶回路群１と、ｂ）前記第１の重みづけ係数群$a_{1,i}$と前記入力信号R_i，（ｉ＝１，２，・・・，Ｎ+１）をそれぞれ入力とするＮ＋１個の第１の乗算回路群$Multi_{1,i}$と、ｃ）ｉ番目（ｉ＝１，２，・・・，Ｎ＋１）の入力信号R_iに対するＮ＋１－ｉ個の第２の重みづけ係数群$a_{i,j}$，（ｊ＝ｉ＋１，ｉ＋２，・・・，Ｎ＋１）を記憶する第２の記憶回路群と、ｄ）前記ｉ番目（ｉ＝１，２，・・・，Ｎ+１）の入力信号R_iと前記第２の重みづけ係数群$a_{i,j}$，（ｊ＝ｉ＋１，ｉ＋２，・・・，Ｎ＋１）を入力とする第２の乗算回路群$Multi_{i,j}$と、ｅ）前記Ｎ＋１個の第１の乗算回路群のｋ番目（ｋ＝２，３，・・・，Ｎ＋１）の乗算回路（$Multi_{k,k}$）の出力と前記第２の乗算回路群のうち$Multi_{n,k}$，（ｎ＝１，２，・・・ｋ－１）の出力を入力とするＮ個の加算器群とを有している。

【０００８】本願のフェージングシミュレータの重み付け合成回路の重み付け係数群において、重みづけ合成回路出力のうちｉ番目の出力とｊ番目の出力との正規化相関係数を$\rho_{i,j}$（＝$\rho_{j,i}$），それぞれの自乗平均値を１．０とするとき、

【０００９】

【数２】

$$\text{a)}\ a_{1,1} = 1.0, a_{1,j} = \rho_{1,j}, a_{2,2} = \sqrt{1.0 - a_{1,2}^2}, (j = 2,3,\cdots,N+1)$$

【００１０】とし、ｂ）ｊ＝３，４，・・・，Ｎ+１の順でｊを固定し、

【００１１】

【数３】

$$a_{i,j} = \frac{\rho_{i,j} - \sum_{k=1}^{i-1} a_{k,i} a_{k,j}}{a_{i,i}}$$

【００１２】に従って、ｉ＝２，３，・・・，ｊ－１について漸化的に求め、さらに、$a_{j,j}$を

【００１３】

【数4】

$$a_{j,j}=\sqrt{1-\sum_{i=1}^{j-1}a_{i,j}^2}$$

【0014】として求めることにより、$a_{i,j}$，j＝1，2，・・・，N＋1　i＝1，2，・・・，jを求めている。

【0015】

【作用】受信レベルの短区間中央値をRとすれば、Rはシャドウイングにより、対数正規分布に従って変動することが知られている（例えば、桑原守二監修、自動車電話、電子情報通信学会発行、コロナ社、昭和60年）。ここで、

【0016】

【数5】

$$X=\log(R)-\log(\bar{R}) \qquad (1)$$

【0017】と変数変換すれば、Xは平均零の正規分布に従う確率変数となる。但し、

【0018】

【外1】

$\bar{R}$

【0019】はRの中央値である。

【0020】本発明では、シャドウイングを表す変数を式1のように変数変換し、正規分布変数として考える。そこで、希望波とN波の干渉波のN＋1波の波が存在する場合を考え、それぞれの波に対するシャドウイングをシミュレートするために、まず、N＋1個の独立な平均が零で分散が1の白色正規乱数、X_1，X_2，・・・，X_{N+1} を発生する。さらに、それぞれのシャドウイングの相関を考慮するために、X_1，X_2，・・・，X_{N+1} を線形結合し、平均零，分散1のそれぞれ相関のある変数変換されたシャドウイングY_1，Y_2，・・・，Y_{N+1} を求めることを考える。ここで、N＋1波のi番目の波とj番目の波の相関係数を$\rho_{i,j}$ とすると、

$\rho_{i,j}=\rho_{j,i}$ 　（2）

が成立するので、対象性を考慮すると、

【0021】

【数6】

$$\begin{pmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_N \\ Y_{N+1} \end{pmatrix} = \begin{pmatrix} a_{1,1}, & 0, & 0, & 0, & \cdots, & 0 \\ a_{1,2}, & a_{2,2}, & 0, & 0, & \cdots, & 0 \\ \vdots & \vdots & \ddots, & \ddots, & \ddots, & \vdots \\ a_{1,N}, & a_{2,N}, & a_{3,N} & \cdots & a_{N,N} & 0 \\ a_{1,N+1}, & a_{2,N+1}, & a_{3,N+1} & \cdots & a_{N,N+1} & a_{N+1,N+1} \end{pmatrix} \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_N \\ X_{N+1} \end{pmatrix} \qquad (3)$$

【0022】で示される方程式を考慮すれば十分である。問題は、この方程式において、

$<Y_i \cdot Y_j>=\rho_{i,j}$ 　（4）

$<Y_i \cdot Y_i>=1.0$ 　（5）

という条件を満たすように、$a_{i,j}$ を定めることができることに帰着する。ここで、$<Y_i \cdot Y_j>$は、Y_i とY_j の平均を示す。$a_{i,j}$ を定めることができれば、変数変換された相関のあるシャドウイングが得られることになる。式（3）及び式（5）と、X_1＋X_2，・・・，X_{N+1} の性質より、

【0023】

【数7】

$$\sum_{j=1}^{i}a_{i,j}^2=1.0 \quad (j\geq i, i,j=1,2,\cdots,N+1) \qquad (6)$$

【0024】が得られる。また、式（3）及び式（4）と、X_1，X_2，・・・，X_{N+1} の性質より、

【0025】

【数8】

$$\rho_{i,j}=\sum_{k=1}^{i}a_{k,i}a_{k,j} \quad (i<j\ i=1,2,\cdots,N\ j=2,3,\cdots,N+1) \qquad (7)$$

【0026】が得られる。ここで、式（6）より、

$a_{1,1}=1.0$　for　i＝1 　（8）

【0027】

【数9】

$$\sum_{j=1}^{i-1}a_{i,j}^2+a_{i,i}^2 = 1.0 \quad for\ i>1 \qquad (9)$$

【0028】が得られる。式（9）より、

【0029】

【数10】

$$a_{i,i}=\sqrt{1.0-\sum_{j=1}^{i-1}a_{i,j}^2} \qquad (10)$$

【0030】が求められる。式（10）は、±の符号が異なる値を取り得るが、ここでは簡単のため、正の値を用いる。一方、式（7）より、＊

＊【0031】
【数11】

$$\rho_{1,j} = \sum_{k=1}^{1} a_{k,1}a_{k,j} = a_{1,j} \quad for\ i = 1, j > i \tag{11}$$

$$\rho_{i,j} = \sum_{k=1}^{i-1} a_{k,i}a_{k,j} + a_{i,i}a_{i,j} \quad for\ i > 1, j > i \tag{12}$$

【0032】が得られる。さらに、式（12）より、※

【0033】
※【数12】

$$a_{i,j} = \frac{\rho_{i,j} - \sum_{k=1}^{i-1} a_{k,i}a_{k,j}}{a_{i,i}} \tag{13}$$

【0034】が得られる。式（6）～式（13）より、$a_{i,j}$ は、図3に示すフローに従って、漸化的に求めることができる。$a_{i,j}$ で与えられる係数を用いてX_1，X_2，・・・，X_{N+1} を重みづけ合成することにより、与えられた相関係数$\rho_{i,j}$，i，j＝1，2，・・・，N＋1で定められる相関を有し、平均零，分散1の正規分布変数Y_1，Y_2，・・・，Y_{N+1} を得る。以上のように得られたY_1，Y_2，Y_{N+1} を、実際のシャドウイングをシミュレートする変数に変換する。すなわち、シ☆

☆ミュレート条件に合うように、シミュレートする希望波及びN＋1波の干渉波に対する分散σ_i と中央値

【0035】
【外2】

$$\bar{R}_i$$

【0036】をそれぞれ乗算及び加算し、式1の逆変換を行なう。この操作は、

【0037】
【数13】

$$R_i = \bar{R}_i 10^{\sigma_i \cdot Y_i} \quad i = 1, 2, \cdots, N + 1 \tag{14}$$

【0038】を行なうことによって実現できる。以上により、目的とする希望波とN＋1波の干渉波の任意の組合せに対する相互相関を有するシャドウイングR_i，i＝1，2，・・・，N＋1を得ることができる。

【0039】
【実施例】本発明を希望波と2波の干渉波を考慮した場合に適用した実施例を図1に示す。図において、100は希望波と2波の干渉波に対するシャドウイングの基となる乱数発生回路群、101は重みづけ合成回路、102はフィルタ群、103は希望波と2波の干渉波に対するシャドウイングの長区間中央値を記憶するメモリ群、104は変数変換回路群、105は加算器群、106は乗算器群、107は希望波と2波の干渉波に対するシャドウイングの分散を記憶するメモリ群、108は出力端子群、109は瞬時変動フェージングシミュレータ群である。乱数発生回路群100では、希望波と2波の干渉波に対するシャドウイングの基となる平均零，分散1で、それぞれが独立となる3つの正規乱数が発生される。これらの乱数群は、重み付け合成回路101に入力され、予め定められた相関が与えられる。

【0040】希望波と2波の干渉波を考慮する場合、重み付け合成回路101は、例えば、図4のように構成することができる。図4において、400～402は入力端子、403～407は乗算器、408，409は加算器、410～414はメモリ、415～417は出力端子である。乱数発生回路群100から出力される、希望波、干渉波1、干渉波2のシャドウイングの基となる乱数は、それぞれ入力端子400～402から入力され、図4に示されるように重み付け合成される。ここで、ρ_{D-I1}，ρ_{D-I2}，ρ_{I1-I2} は、希望波－干渉波1、希望波－干渉波2、干渉波1－干渉波2に生じさせる予め定められた相関係数であり、メモリ410～413には、ρ_{D-I1}，ρ_{D-I2}，ρ_{I1-I2} を変数として、

【0041】
【数14】

$$410 = \rho_{D-I1} \tag{15}$$

$$414 = \rho_{D-I2} \tag{16}$$

$$411 = \sqrt{1-\rho_{D-I1}^2} \tag{17}$$

$$412 = \frac{\rho_{I1-I2} - \rho_{D-I1}\cdot\rho_{D-I2}}{\sqrt{1-\rho_{D-I1}^2}} \tag{18}$$

$$413 = \sqrt{1-\rho_{D-I2}^2 - \frac{(\rho_{I1-I2} - \rho_{D-I1}\cdot\rho_{D-I2})^2}{1-\rho_{D-I1}^2}} \tag{19}$$

【００４２】で与えられる値を記憶している。乱数発生回路群１００から発生された乱数群は、メモリ４１０～４１４、加算器４０８，４０９及び乗算器４０３～４０６によって重み付けされ、所望の相関が付加されて、出力端子４１５～４１７から、希望波、干渉波１、干渉波２に対する相関のあるシャドウイングを示す乱数としてそれぞれ出力される。

【００４３】一般に、希望波とＮ波の干渉波のＮ＋１波を考慮する場合、ｊ，（ｊ＝１，２，・・・，Ｎ＋１）番目の入力乱数に対する重み付け合成回路の部分は、図５のように構成することができる。図５において、５００－１～５００－ｊは入力端子群、５０１－１～５０１－（ｊ－１）及び５０２は乗算器、５０３は加算器、５０４－１～５０４－ｊはメモリ、５０５は出力端子である。Ｎ＋１波を考慮する場合、Ｎ＋１個の乱数発生回路から乱数が発生され、ｊ番目の乱数に対しては、１，２，・・・，ｊ番目の乱数発生回路からの信号が入力端子５００－１～５００－ｊからそれぞれ入力される。入力されたｊ個の乱数は、図５のように、重み係数 $a_{1,j}$，$a_{2,j}$，・・・，$a_{j,j}$ のｊ個の係数を用いて、重み付けされる。ここで、$a_{1,j}$，$a_{2,j}$，・・・，$a_{j,j}$ のｊ個の係数は、それぞれの波の任意の組合せに相互相関係数 $\rho_{i,j}$，（ｉ＝１，２，・・・，ｊ　ｊ＝１，２，・・・，Ｎ＋１）が与えられれば、図３に示すフローに従って、漸化的に求めることができる。

【００４４】以上のようにして得られた重み付け合成回路１０１からの出力は、平均０，分散１の相関のある正規乱数である。ここで、各波のシャドウイングに対する適切な時間変動を与えるために、重み付け合成回路１０１のそれぞれの出力をフィルタ群１０２により平滑化を行なう。ここで、フィルタ群１０２のそれぞれの伝達関数 $H_i(\omega)$ は、

$$|H_i(\omega)|^2 = 1.0 \qquad (20)$$

の条件を満たしており、直流オフセットを生じさせないものを用いることにより、それぞれの乱数の分散及び平均は保存される。フィルタ群１０２の出力に応じて、所望のシャドウイングの分散を与えるために、メモリ群１０７に記憶されている各波に対するシャドウイングの分散を乗算するとともに、メモリ群１０３に記憶されている各波の長区間中央値を加算するさらに、変数変換回路群１０４では、分散と中央値がそれぞれ乗算、加算された正規乱数を、式（１４）に基づいて対数正規分布乱数に変換し、所望の相互相関が生じるシャドウイングを得る。以上のようにして得られた各波のシャドウイングを、例えば、既存の瞬時変動フェージングシミュレータ群１０９（レイリーフェージングシミュレータ）に入力し、与えられたシャドウイングに基づいた瞬時変動を与えることにより、より精密な伝搬環境をシミュレートすることができる。

【００４５】尚、本発明は、ソフトウェアを用いて実装することも可能である。また、本実施例において、重み付け合成回路１０１、フィルタ群１０２、中央値加算部（希望波と２波の干渉波に対するシャドウイングの長区間中央値を記憶するメモリ群１０３及び加算器群１０５）、分散乗算部（希望波と２波の干渉波に対するシャドウイングの分散を記憶するメモリ群１０７及び乗算器群１０６）は、全て線形操作であるから順番を入れ換えて実施しても、同等の効果を得ることができる。

【００４６】

【発明の効果】本発明により、陸上移動通信において生じるシャドウイングに対し、希望波及び干渉波の任意の組合せに対する相互相関を考慮したシミュレーションを容易に行なうことが可能になる。

【図面の簡単な説明】

【図１】本願の第１の発明を希望波と２波の干渉波を考慮した場合に適用した実施例を示す系統図である。

【図２】従来の技術を示す系統図である。

【図３】重みづけ合成回路１０１の重み係数を求めるフローを示すフローチャートである。

【図４】希望波と２波の干渉波を考慮した場合の重みづけ合成回路の実施例を示す系統図である。

【図５】一般にＮ＋１波を考慮した場合の第ｊ番目の乱数発生回路の出力に対する重み付け回路構成を示す系統図である。

【符号の説明】

１００　希望波と２波の干渉波に対するシャドウイングの基となる乱数発生回路群

１０１　重みづけ合成回路

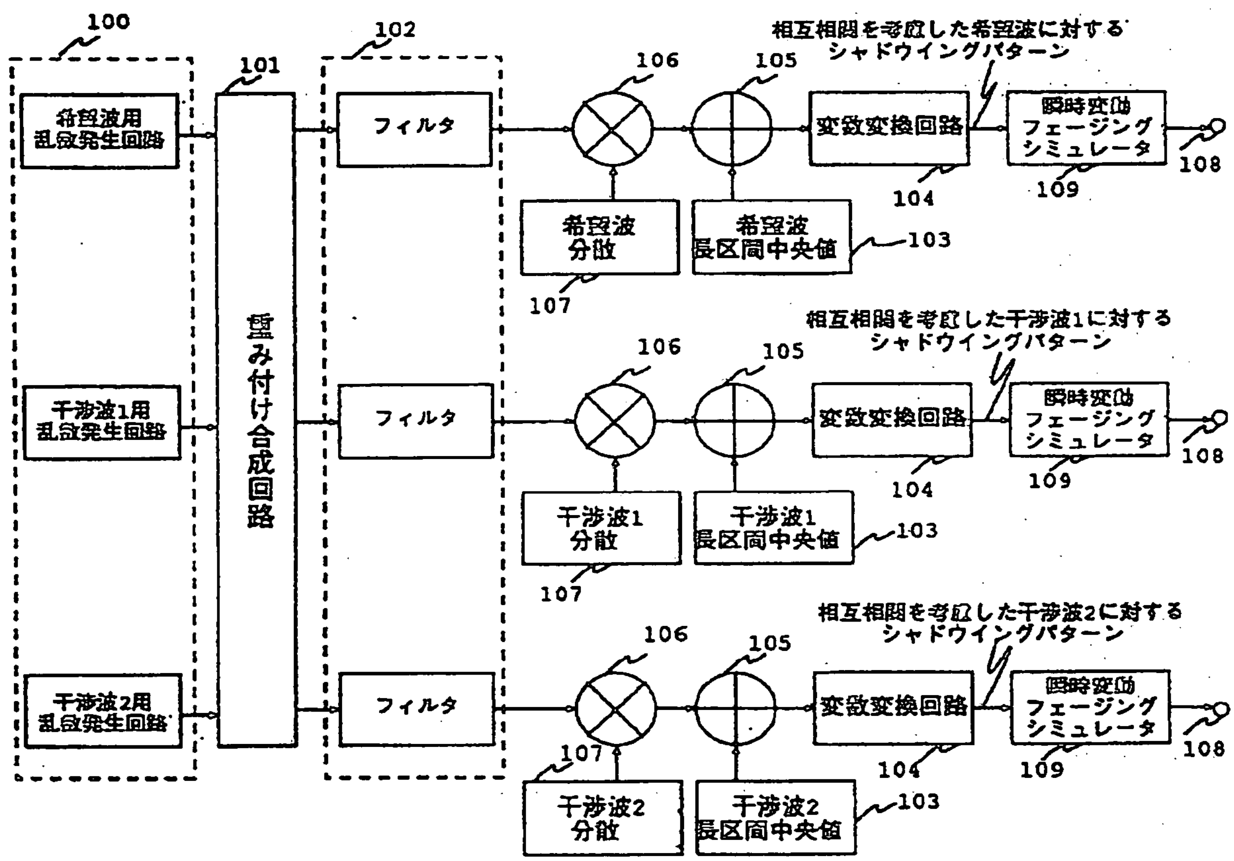
１０２　フィルタ群

１０３　希望波と２波の干渉波に対するシャドウイング

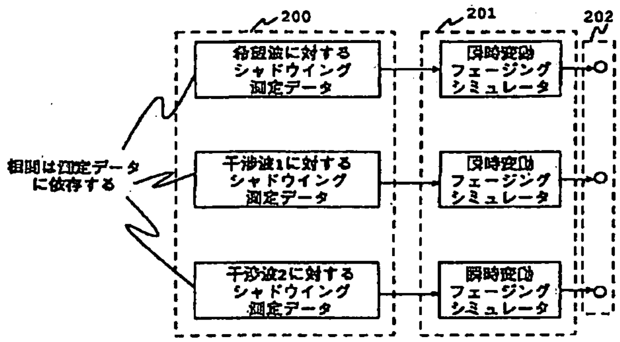
の長区間中央値を記憶するメモリ群
104　変数変換回路群
105　加算器群
106　乗算器群
107　希望波と２波の干渉波に対するシャドウイングの分散を記憶するメモリ群
108　出力端子群
109　瞬時変動フェージングシミュレータ群
200　測定実験で得られたシャドウイングデータを記憶するメモリ回路群
201　瞬時変動フェージングをシミュレートするレイリーフェージングシミュレータ群 ＊

＊202　出力端子群
400～402　入力端子
403～407　乗算器
408，409　加算器
410～414　メモリ
415～417　出力端子
500－1～500－j　入力端子群
501－1～501－（j－1），502　乗算器
503　加算器
504－1～504－j　メモリ
505　出力端子

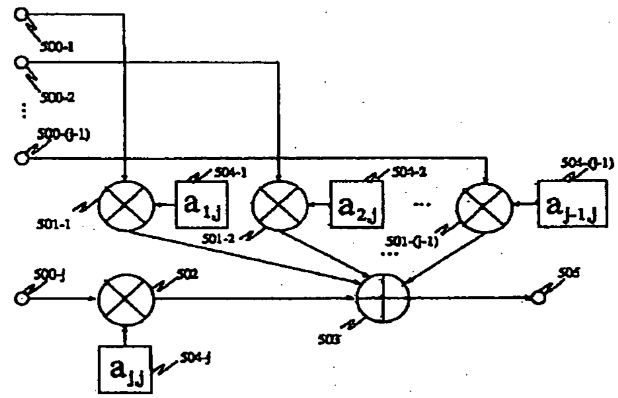
【図１】



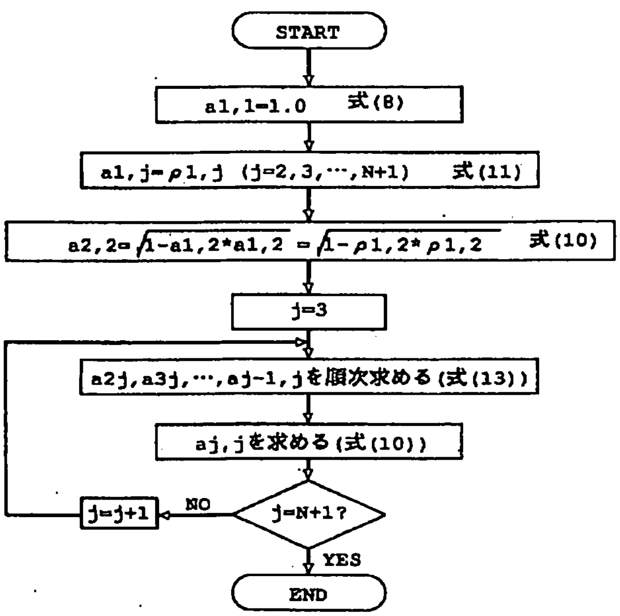
【図２】


200
201
202
希望波に対する
シャドウイング
測定データ
干渉波1に対する
シャドウイング
測定データ
干渉波2に対する
シャドウイング
測定データ
瞬時変動
フェージング
シミュレータ
相関は測定データ
に依存する

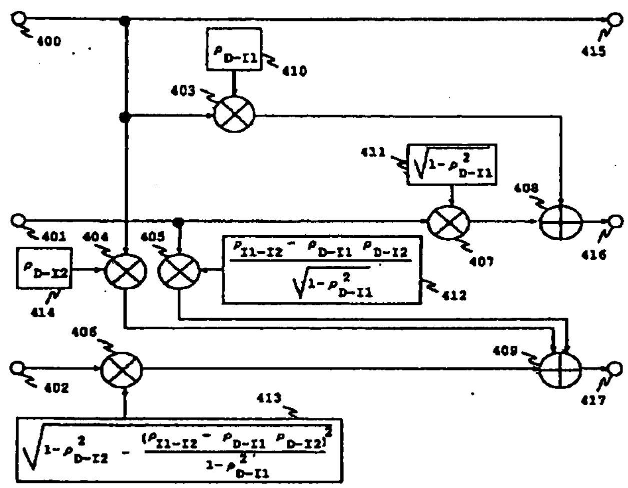
【図５】



【図３】


START
a1,1=1.0　式(8)
a1,j=ρ1,j (j=2,3,…,N+1)　式(11)
a2,2=√(1-a1,2*a1,2) = √(1-ρ1,2*ρ1,2)　式(10)
j=3
a2j,a3j,…,aj-1,jを順次求める(式(13))
aj,jを求める(式(10))
j=N+1?
NO
j=j+1
YES
END

【図4】


400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
ρD-I1
ρD-I2

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CLAIMS

[Claim(s)]
[Claim 1] In the phasing simulator treating the wave of N+1 wave which consists of the wave of choice, and N wave interference wave a) N+1 random-number-generation circuit group which generates a respectively independent white normal random number process (N is the natural number), b) Input the output from said N+1 normal random number generating circuit group, and weighting composition of each input signal is carried out. The weighting composition circuit which outputs a random-number sequence group with N+1 correlation, and N+1 low-pass filter group which considers each of the random-number sequence group with N+1 correlation obtained from the c aforementioned weighting composition circuit as an input, d) The 1st N+1 store circuit group which memorizes distribution of the short section median fluctuation to the wave of said wave of choice and N wave, e) N+1 multiplier group which carries out the multiplication of the output of said N+1 low-pass filter group to the value memorized by said 1st store circuit group, f) The 2nd N+1 store circuit group which memorizes the long section median over the wave of said wave of choice and N wave, g) N+1 adder group which adds the long section median over the wave of said wave of choice memorized by said 2nd N+1 store circuit group, and a N wave to each output of said N+1 multiplier group, h) Phasing simulator characterized by having the change-of-variables circuit which performs a change of variables to the output of said N+1 adder group.
[Claim 2] N+1 normal random number generating circuit group according to claim 1 -- setting -- a -- the phasing simulator according to claim 1 characterized by what the independent white normal random number process generated from said N+1 normal random number generating circuit group has respectively equal distribution for.
[Claim 3] As opposed to 1, 2, ..., N+1 a weighting composition circuit according to claim 1 -- setting -- N+1 input signal (N is the natural number), Ri, and i= -- a) 1st [to an input signal Ri (i= 1, 2, ..., N+1)] weighting multiplier group ai and i The store circuit group 1 to memorize, b) -- said 1st weighting multiplier group ai and i 1st N+1 multiplication circuit group Multii and i which considers said input signal Ri (i= 1, 2, ..., N+1) as an input, respectively c) i-th input signal Ri (i= 1, 2, ..., N+1) The 2nd N+1-i receiving weighting multiplier group ai and j and the 2nd store circuit group which memorizes (j=i +1, i+2, ..., N+1), d) -- said i-th input signal (i= 1, 2, ..., N+1) Ri Said 2nd weighting multiplier group ai and j and 2nd multiplication circuit group Multii and j which considers (j=i +1, i+2, ..., N+1) as an input e) -- the inside of the output of the k-th multiplication circuit (k= 2, 3, .., N+1) (Multik and k) of said 1st N+1 multiplication circuit group, and said 2nd multiplication circuit group -- Multin and k -- (-- n= -- the adder group of 1, 2, ..., N individual that considers the output of k-1) as an input Claim 1 characterized by having, and a phasing simulator given in two.
[Claim 4] the 1st and the 2nd weighting multiplier group according to claim 3, and ai and j -- (-- i= -- 1, 2, ..., N+1 j=i, i+1, ..., N+1) -- setting -- the inside of a weighting composition circuit output -- the normalization correlation coefficient of the i-th output and the j-th output -- rho -- i, j (=rho j and i), and each square -- the time of setting the average to 1.0 -- [Equation 1]

a) $a_{1,1} = 1.0, a_{1,j} = \rho_{1,j}, a_{2,2} = \sqrt{1.0 - a_{1,2}^2}, (j = 2, 3, \cdots, N+1)$ とし,

b) $j = 3, 4, \cdots, N+1$ の順で j を固定し, $a_{i,j} = \frac{\rho_{i,j} - \sum_{k=1}^{i-1} a_{k,i} a_{k,j}}{a_{i,i}}$ に従って, $i = 2, 3, \cdots, j-1$ について漸化的に求め, さらに, $a_{j,j}$ を $a_{j,j} = \sqrt{1 - \sum_{i=1}^{j-1} a_{i,j}^2}$ として求め, 漸化的に $a_{i,j}, j = 1, 2, \cdots, N+1 \;\; i = 1, 2, \cdots, j$ を求める

Claims 1 and 2 characterized by things, and a phasing simulator given in three.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the high phasing simulator of the versatility which can simulate the channel in consideration of correlation of shadowing produced on the wave of choice, and N wave interference wave.
[0002]
[Description of the Prior Art] The following three phenomena can be mentioned as a factor by which the radio-wave-propagation environment in a land-mobile communication link is characterized.
[0003] 1. Phenomenon of Changing Receiving Level Sharply if Sending Station or Receiving Station Carries Out Subcarrier Wavelength Order Extent Migration in order to Receive Signal with which Wave whose Difference of Travelling Distance is Subcarrier Wavelength Order Extent was Compounded (Rayleigh Fading)
2. Phenomenon Which Distortion by Ghost or Intersymbol Interference Produces when Wave more than Inverse Number Order of Signal Bandwidth is Compounded for Difference of Travelling Distance (Frequency Selective Phasing)
3. Fluctuation of Received Signal Level by Signal being Interrupted with Building and Tree of Sending Station or Perimeter of Receiving Station (Shadowing, Short Section Median Fluctuation)
In a land-mobile communication link, since these phenomena compound and arise, it is necessary to take a very complicated propagation model into consideration. In order to simulate such a propagation environment, the thing (for example, Ichiro Tsujimoto, a "phasing simulator", Japanese Patent Application No. 2-86352) in consideration of frequency selective phasing and Rayleigh fading is known. on the other hand, as a simulator also in consideration of the effectiveness of shadowing, the thing of a configuration of simulate Rayleigh fading based on the value be know like drawing 2 using the data of the received signal level fluctuation by shadowing obtained by conduct the experiment which discharge an electric wave actually (the Kanai ****, ********, Seiji Kondo, the Furuya **** "the high-speed hand off method experiment system for digital mobile communication", the Institute of Electronics, Information and Communication Engineers, a radio communications system seminar technical report, RCS89-1989 [37 or]).
[0004]
[Problem(s) to be Solved by the Invention] As mentioned above, as a phasing simulator in consideration of shadowing, only the thing using the data based on an experiment is known, but versatility is dramatically low. Furthermore, in cellular system, the exaggerated reach of an electric wave etc. will receive the electric wave from two or more base stations which exist in the various directions with a mobile station. It is thought that mutually related high shadowing has produced shadowing from the base station which sees from a receiving point and exists in the same direction since it is generated with the surrounding building and surrounding tree of a transmitting point or a receiving point to the electric wave, and mutually related low shadowing has arisen from a base station which tends to be different to an electric wave, and in order to obtain the high simulator of versatility in this way, it is necessary to also take correlation of

shadowing into consideration.
[0005]
[Means for Solving the Problem] In the phasing simulator treating the wave of N+1 wave which consists of the wave of choice which is this invention, and N wave interference wave a) N+1 random-number-generation circuit group which generates a respectively independent white normal random number process (N is the natural number), b) Input the output from said N+1 normal random number generating circuit group, and weighting composition of each input signal is carried out. The weighting composition circuit which outputs a random-number sequence group with N+1 correlation, and N+1 low-pass filter group which considers each of the random-number sequence group with N+1 correlation obtained from the c aforementioned weighting composition circuit as an input, d) The 1st N+1 store circuit group which memorizes distribution of the short section median fluctuation to the wave of said wave of choice and N wave, e) N+1 multiplier group which carries out the multiplication of the output of said N+1 low-pass filter group to the value memorized by said 1st store circuit group, f) The change-of-variables circuit which performs a change of variables to the output of said N+1 multiplier group, g) The 2nd N+1 store circuit group which memorizes the long section median over the wave of said wave of choice and N wave, h) It has N+1 adder group adding the long section median over the wave of said wave of choice memorized by said 2nd N+1 store circuit group, and a N wave to each output of said N+1 change-of-variables circuit group.
[0006] the normal random number generating circuit group of the phasing simulator of this invention -- setting -- a -- what has respectively equal distribution is used for the independent white normal random number process generated from said N+1 normal random number generating circuit group.
[0007] In the weighting composition circuit of the phasing simulator of this invention As opposed to 1, 2, ..., N+1 N+1 input signal (N is the natural number), Ri, and i= -- a) -- an input signal Ri -- (-- i= -- 1, 2, ..., 1st [to N+1)] weighting multiplier group ai and i With the store circuit group 1 to memorize b) -- said 1st weighting multiplier group ai and i said input signal Ri -- (-- i= -- 1st N+1 multiplication circuit group Multii and i which considers 1, 2, ..., N+1) as an input, respectively c) i-th input signal Ri (i= 1, 2, ..., N+1) The 2nd N+1-i receiving weighting multiplier group ai and j and the 2nd store circuit group which memorizes (j=i +1, i+2, ..., N+1), d) -- said i-th input signal (i= 1, 2, ..., N+1) Ri Said 2nd weighting multiplier group ai and j and 2nd multiplication circuit group Multii and j which considers (j=i +1, i+2, ..., N+1) as an input e) -- the inside of the output of the k-th multiplication circuit (k= 2, 3, ..., N+1) (Multik and k) of said 1st N+1 multiplication circuit group, and said 2nd multiplication circuit group -- Mutiln and k -- (-- n= -- 1, 2, and ... it has the adder group of N individual which considers the output of k-1) as an input.
[0008] the weighting multiplier group of the weighting composition circuit of the phasing simulator of this application -- setting -- the inside of a weighting composition circuit output -- the normalization correlation coefficient of the i-th output and the j-th output -- rho -- i, j (=rho j and i), and each square -- the time of setting the average to 1.0 -- [0009]
[Equation 2]
$$\text{a)}\ a_{1,1} = 1.0, a_{1,j} = \rho_{1,j}, a_{2,2} = \sqrt{1.0 - a_{1,2}^2}, (j = 2, 3, \cdots, N+1)$$
[0010] ** -- carrying out -- bj= -- 3, 4, ..., the order of N+1 -- j -- fixing -- [0011]
[Equation 3]
$$a_{i,j} = \frac{\rho_{i,j} - \sum_{k=1}^{i-1} a_{k,i} a_{k,j}}{a_{i,i}}$$
[0012] alike -- following -- i= -- 2, 3, ..., j-1 -- ** ---izing ---like -- asking -- further -- aj and j -- [0013]
[Equation 4]
$$a_{j,j} = \sqrt{1 - \sum_{i=1}^{j-1} a_{i,j}^2}$$
[0014] what is searched for by carrying out -- ai, j, and j= -- 1, 2, ..., N+1 i= -- it is asking for 1,

2, ..., j.
[0015]
[Function] Changing R, then R by shadowing according to log normal distribution is known in the short section median of receiving level (for example, Moriji Kuwahara editorial supervision, a land mobile radiotelephone, the Institute of Electronics, Information and Communication Engineers issuance, Corona Publishing, Showa 60). It is here and is [0016].
[Equation 5]

$$X = \log(R) - \log(\bar{R}) \qquad (1)$$

[0017] If a change of variables is carried out, X will serve as a random variable according to an average of 0 normal distribution. However, [0018]
[External Character 1]

$\bar{R}$

[0019] It is the median of ** R.
[0020] By this invention, the change of variables of the variable showing shadowing is carried out like a formula 1, and it thinks as a normal-distribution variable. Then, in order to consider the case where the wave of N+1 wave of the wave of choice and N wave interference wave exists and to simulate shadowing to each wave, for the independent average of N+1 piece, distribution is the white normal random number of 1, X1, X2, ..., XN+1 at zero first. It generates. Furthermore, in order to take correlation of each shadowing into consideration, it is X1, X2, ..., XN+1. Linear combination is carried out and the an average of 0 distribution 1 is each the shadowing Y1 with correlation by which the change of variables was carried out, Y2, ..., YN+1. It considers asking. here -- the correlation coefficient of the i-th wave of N+1 wave, and the j-th wave -- rho -- i and j ** -- if it carries out -- rhoi and j =rho -- j and i (2)
It is [0021] when object nature is taken into consideration, since it ******.
[Equation 6]

$$\begin{pmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_N \\ Y_{N+1} \end{pmatrix} = \begin{pmatrix} a_{1,1}, & 0, & 0, & 0, & \cdots, & 0 \\ a_{1,2}, & a_{2,2}, & 0, & 0, & \cdots, & 0 \\ \vdots & \vdots & \ddots & \ddots & \ddots, & \vdots \\ a_{1,N}, & a_{2,N}, & a_{3,N} & \cdots & a_{N,N} & 0 \\ a_{1,N+1}, & a_{2,N+1}, & a_{3,N+1} & \cdots & a_{N,N+1} & a_{N+1,N+1} \end{pmatrix} \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_N \\ X_{N+1} \end{pmatrix} \qquad (3)$$

[0022] It is enough, if it comes out and the equation shown is taken into consideration. It sets to this equation and a problem is <Yi and Yj> =rhoi and j. (4)
<Yi and Yi> =1.0 (5)
They are ai and j so that the conditions to say may be fulfilled. It comes back to the ability to set. Here, <Yi and Yj> are Yi. Yj An average is shown. ai and j If it can set, shadowing with the correlation by which the change of variables was carried out will be obtained. A formula (3) and a formula (5), and X1+X2, ... and XN+1 From a property, it is [0023].
[Equation 7]

$$\sum_{j=1}^{i} a_{i,j}^2 = 1.0 \quad (j \geq i, i, j = 1, 2, \cdots, N+1) \qquad (6)$$

[0024] **********. Moreover, a formula (3) and a formula (4), and X1, X2, ... and XN+1 From a property, it is [0025].
[Equation 8]

$$\rho_{i,j} = \sum_{k=1}^{i} a_{k,i} a_{k,j} \quad (i < j \; i = 1, 2, \cdots, N \; j = 2, 3, \cdots, N+1) \qquad (7)$$

[0026] **********. Here, it is a1 and 1 = 1.0 from a formula (6). for i= 1 (8)
[0027]
[Equation 9]

$$\sum_{j=1}^{i-1} a_{i,j}^2 + a_{i,i}^2 = 1.0 \quad for \; i > 1 \qquad (9)$$

[0028] **********. From a formula (9), it is [0029].
[Equation 10]

$$a_{i,i} = \sqrt{1.0 - \sum_{j=1}^{i-1} a_{i,j}^2} \qquad (10)$$

[0030] **** ****. Although a formula (10) can take the value from which the sign of ** differs, since it is easy here, a forward value is used for it. On the other hand, it is [0031] from a formula (7).
[Equation 11]

$$\rho_{1,j} = \sum_{k=1}^{1} a_{k,1} a_{k,j} = a_{1,j} \quad for \; i = 1, j > i \qquad (11)$$

$$\rho_{i,j} = \sum_{k=1}^{i-1} a_{k,i} a_{k,j} + a_{i,i} a_{i,j} \quad for \; i > 1, j > i \qquad (12)$$

[0032] **********. Furthermore, it is [0033] from a formula (12).
[Equation 12]

$$a_{i,j} = \frac{\rho_{i,j} - \sum_{k=1}^{i-1} a_{k,i} a_{k,j}}{a_{i,i}} \qquad (13)$$

[0034] **********. a formula (6) - a formula (13) -- ai and j the flow shown in drawing 3 -- following -- ** -- it can ask in-izing. ai and j the multiplier given -- using -- X1, X2, ..., XN+1 the correlation coefficient rho given by carrying out weighting composition -- i, j, i, and j= -- the correlation defined by 1, 2, ..., N+1 -- having -- the normal-distribution variable Y1 of the an average of 0 distribution 1, Y2, ..., YN+1 It obtains. Y1 obtained as mentioned above, Y2, and YN+1 It changes into the variable which simulates actual shadowing. Namely, distributed sigmai to the interference wave of the wave of choice simulated so that simulation conditions may be suited, and N+1 wave Median [0035]
[External Character 2]
$\bar{R}_i$

[0036] each -- multiplication -- and it adds and inverse transformation of a formula 1 is performed. This actuation is [0037].
[Equation 13]

$$R_i = \bar{R}_i 10^{\sigma_i \cdot Y_i} \quad i = 1, 2, \cdots, N+1 \qquad (14)$$

[0038] ******** -- it is realizable with things. the shadowing Ri which has a cross-correlation over the combination of the arbitration of the interference wave of the wave of choice made into the object, and N+1 wave by the above, and i= -- 1, 2, ..., N+1 can be obtained.
[0039]
[Example] The example which applied this invention when the interference wave of the wave of choice and two waves was taken into consideration is shown in drawing 1 . The random-number-generation circuit group from which 100 becomes the radical of shadowing to the interference

wave of the wave of choice, and two waves in drawing, The memory group 101 remembers the long section median of shadowing [as opposed to / as opposed to / in a weighting composition circuit and 102 / a filter group / the interference wave of the wave of choice, and two waves in 103] to be, As for the memory group which memorizes distribution of shadowing [as opposed to / 104 / 105 / a change-of-variables circuit group and / as opposed to / in an adder group and 106 / a multiplier group / the interference wave of the wave of choice, and two waves in 107], and 108, an output terminal group and 109 are instant fluctuation phasing simulator groups. By the random-number-generation circuit group 100, the three normal random numbers with which each becomes independent are generated in the an average of 0 distribution 1 used as the radical of shadowing to the interference wave of the wave of choice, and two waves. These random-number groups are inputted into the weighting composition circuit 101, and the correlation defined beforehand is given.

[0040] When taking into consideration the interference wave of the wave of choice, and two waves, the weighting composition circuit 101 can be constituted like drawing 4 . As for an adder, and 410-414, for an input terminal, and 403-407, in drawing 4 , memory, and 415-417 are [400-402 / a multiplier and 408,409] output terminals. The random number used as the radical of shadowing of the wave of choice outputted from the random-number-generation circuit group 100, an interference wave 1, and an interference wave 2 is inputted from input terminals 400-402, respectively, and weighting composition is carried out as shown in drawing 4 . Here, it is rhoD-I1, rhoD-I2, and rhoI1-I2. It is the correlation coefficient which the wave of choice-interference wave 1, the wave of choice-interference wave 2, and the interference wave 1-interference wave 2 are made to produce and which was defined beforehand, and is rhoD-I1, rhoD-I2, and rhoI1-I2 in memory 410-413. It considers as a variable and is [0041].

[Equation 14]

$$410 = \rho_{D-I1} \quad (15)$$

$$414 = \rho_{D-I2} \quad (16)$$

$$411 = \sqrt{1-\rho_{D-I1}^2} \quad (17)$$

$$412 = \frac{\rho_{I1-I2} - \rho_{D-I1}\cdot\rho_{D-I2}}{\sqrt{1-\rho_{D-I1}^2}} \quad (18)$$

$$413 = \sqrt{1-\rho_{D-I2}^2 - \frac{(\rho_{I1-I2} - \rho_{D-I1}\cdot\rho_{D-I2})^2}{1-\rho_{D-I1}^2}} \quad (19)$$

[0042] The value come out of and given is memorized. Weighting is carried out by memory 410-414, the adder 408,409, and multipliers 403-406, desired correlation is added, and the random-number group generated from the random-number-generation circuit group 100 is outputted, respectively as a random number in which shadowing with the correlation over the wave of choice, an interference wave 1, and an interference wave 2 is shown from output terminals 415-417.

[0043] Generally, when taking into consideration N+1 of the wave of choice, and N wave interference wave wave, the part of the weighting composition circuit to the input random number of j and eye watch (j= 1, 2, ..., N+1) can be constituted like drawing 5 . For an input terminal group, 501-1 - 501- (j-1), and 502, as for an adder, and 504-1 - 504-j, in drawing 5 , a multiplier and 503 are [500-1 - 500-j / memory and 505] output terminals. When taking N+1 wave into consideration, a random number is generated from N+1 random-number-generation circuit, and the signal from 1, 2, ..., the j-th random-number-generation circuit is inputted from an input terminal 500-1 - 500-j to the j-th random number, respectively. j inputted random numbers are weighting factors a1 and j, a2 and j, ..., aj and j like drawing 5 . Weighting is carried out using the multiplier of j pieces. here -- a1, j, a2 and j, ..., aj and j the multiplier of j pieces -- the combination of the arbitration of each wave -- a cross correlation function rho -- i and j -- (-- i= -- 1, 2, ..., j j= -- the flow shown in drawing 3 if 1, 2, ..., N+1) is given -- following -- ** -- it can ask in-izing.

[0044] The output from the weighting composition circuit 101 obtained as mentioned above is the normal random number with correlation of the an average of 0 distribution 1. In order to give the suitable time variation to shadowing of each wave here, each output of the weighting composition circuit 101 is graduated by the filter group 102. Here, each transfer function Hj (omega) of the filter group 102 is |Hj |(omega)2 =1.0. (20)
****** is filled and distribution and an average of each random number are saved by using what does not produce direct current offset. In order to give distribution of desired shadowing according to the output of the filter group 102 While carrying out the multiplication of the distribution of shadowing to each wave memorized by the memory group 107 To the pan adding the long section median of each wave memorized by the memory group 103, by the change-of-variables circuit group 104, distribution and a median change multiplication and the added normal random number into a log-normal-distribution random number based on a formula (14), respectively, and shadowing which a desired cross-correlation produces is obtained. A more precise propagation environment can be simulated by inputting into the existing instant fluctuation phasing simulator group 109 (Rayleigh fading simulator) shadowing of each wave obtained as mentioned above, and giving the instant fluctuation based on given shadowing.
[0045] In addition, this invention can also be mounted using software. In this example Moreover, the weighting composition circuit 101, the filter group 102, a median adder unit (the memory group 103 and the adder group 105 which memorize the long section median of shadowing to the interference wave of the wave of choice, and two waves), Since all the distributed multiplication sections (the memory group 107 and the multiplier group 106 which memorize distribution of shadowing to the interference wave of the wave of choice and two waves) are linearity actuation, even if they replace and carry out sequence, they can acquire equivalent effectiveness.
[0046]
[Effect of the Invention] This invention enables it to perform easily simulation in consideration of the cross-correlation over the combination of the arbitration of the wave of choice, and an interference wave to shadowing produced in a land-mobile communication link.

[Translation done.]

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TECHNICAL FIELD

[Industrial Application] This invention relates to the high phasing simulator of the versatility which can simulate the channel in consideration of correlation of shadowing produced on the wave of choice, and N wave interference wave.

[Translation done.]

* NOTICES *

PRIOR ART

[Description of the Prior Art] The following three phenomena can be mentioned as a factor by which the radio-wave-propagation environment in a land-mobile communication link is characterized.
[0003] 1. Phenomenon of Changing Receiving Level Sharply if Sending Station or Receiving Station Carries Out Subcarrier Wavelength Order Extent Migration in order to Receive Signal with which Wave whose Difference of Travelling Distance is Subcarrier Wavelength Order Extent was Compounded (Rayleigh Fading)
2. Phenomenon Which Distortion by Ghost or Intersymbol Interference Produces when Wave more than Inverse Number Order of Signal Bandwidth is Compounded for Difference of Travelling Distance (Frequency Selective Phasing)
3. Fluctuation of Received Signal Level by Signal being Interrupted with Building and Tree of Sending Station or Perimeter of Receiving Station (Shadowing, Short Section Median Fluctuation)
In a land-mobile communication link, since these phenomena compound and arise, it is necessary to take a very complicated propagation model into consideration. In order to simulate such a propagation environment, the thing (for example, Ichiro Tsujimoto, a "phasing simulator", Japanese Patent Application No. 2-86352) in consideration of frequency selective phasing and Rayleigh fading is known. on the other hand, as a simulator also in consideration of the effectiveness of shadowing, the thing of a configuration of simulate Rayleigh fading based on the value be know like drawing 2 using the data of the received signal level fluctuation by shadowing obtained by conduct the experiment which discharge an electric wave actually (the Kanai ****, ********, Seiji Kondo, the Furuya **** "the high-speed hand off method experiment system for digital mobile communication", the Institute of Electronics, Information and Communication Engineers, a radio communications system seminar technical report, RCS89-1989 [37 or]).

[Translation done.]

* NOTICES *

EFFECT OF THE INVENTION

[Effect of the Invention] This invention enables it to perform easily simulation in consideration of the cross-correlation over the combination of the arbitration of the wave of choice, and an interference wave to shadowing produced in a land-mobile communication link.

[Translation done.]

* NOTICES *

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] As mentioned above, as a phasing simulator in consideration of shadowing, only the thing using the data based on an experiment is known, but versatility is dramatically low. Furthermore, in cellular system, the exaggerated reach of an electric wave etc. will receive the electric wave from two or more base stations which exist in the various directions with a mobile station. It is thought that mutually related high shadowing has produced shadowing from the base station which sees from a receiving point and exists in the same direction since it is generated with the surrounding building and surrounding tree of a transmitting point or a receiving point to the electric wave, and mutually related low shadowing has arisen from a base station which tends to be different to an electric wave, and in order to obtain the high simulator of versatility in this way, it is necessary to also take correlation of shadowing into consideration.

[Translation done.]

* NOTICES *

MEANS

[Means for Solving the Problem] In the phasing simulator treating the wave of N+1 wave which consists of the wave of choice which is this invention, and N wave interference wave a) N+1 random-number-generation circuit group which generates a respectively independent white normal random number process (N is the natural number), b) Input the output from said N+1 normal random number generating circuit group, and weighting composition of each input signal is carried out. The weighting composition circuit which outputs a random-number sequence group with N+1 correlation, and N+1 low-pass filter group which considers each of the random-number sequence group with N+1 correlation obtained from the c aforementioned weighting composition circuit as an input, d) The 1st N+1 store circuit group which memorizes distribution of the short section median fluctuation to the wave of said wave of choice and N wave, e) N+1 multiplier group which carries out the multiplication of the output of said N+1 low-pass filter group to the value memorized by said 1st store circuit group, f) The change-of-variables circuit which performs a change of variables to the output of said N+1 multiplier group, g) The 2nd N+1 store circuit group which memorizes the long section median over the wave of said wave of choice and N wave, h) It has N+1 adder group adding the long section median over the wave of said wave of choice memorized by said 2nd N+1 store circuit group, and a N wave to each output of said N+1 change-of-variables circuit group.
[0006] the normal random number generating circuit group of the phasing simulator of this invention -- setting -- a -- what has respectively equal distribution is used for the independent white normal random number process generated from said N+1 normal random number generating circuit group.
[0007] In the weighting composition circuit of the phasing simulator of this invention As opposed to 1, 2, ..., N+1 N+1 input signal (N is the natural number), Ri, and i= -- a) -- an input signal Ri -- (-- i= -- 1, 2, ..., 1st [to N+1)] weighting multiplier group ai and i With the store circuit group 1 to memorize b) -- said 1st weighting multiplier group ai and i said input signal Ri -- (-- i= -- 1st N+1 multiplication circuit group Multii and i which considers 1, 2, ..., N+1) as an input, respectively c) i-th input signal Ri (i= 1, 2, ..., N+1) The 2nd N+1-i receiving weighting multiplier group ai and j and the 2nd store circuit group which memorizes (j=i +1, i+2, ..., N+1), d) -- said i-th input signal (i= 1, 2, ..., N+1) Ri Said 2nd weighting multiplier group ai and j and 2nd multiplication circuit group Multii and j which considers (j=i +1, i+2, ..., N+1) as an input e) -- the inside of the output of the k-th multiplication circuit (k= 2, 3, ..., N+1) (Multik and k) of said 1st N+1 multiplication circuit group, and said 2nd multiplication circuit group -- Mutiln and k -- (-- n= -- 1, 2, and ... it has the adder group of N individual which considers the output of k-1) as an input.
[0008] the weighting multiplier group of the weighting composition circuit of the phasing simulator of this application -- setting -- the inside of a weighting composition circuit output -- the normalization correlation coefficient of the i-th output and the j-th output -- rho -- i, j (=rho j and i), and each square -- the time of setting the average to 1.0 -- [0009]
[Equation 2]
a) $a_{1,1} = 1.0, a_{1,j} = \rho_{1,j}, a_{2,2} = \sqrt{1.0 - a_{1,2}^2}, (j = 2, 3, \cdots, N+1)$

[0010] ** -- carrying out -- bj= -- 3, 4, ..., the order of N+1 -- j -- fixing -- [0011]

[Equation 3]

$$a_{i,j} = \frac{\rho_{i,j} - \sum_{k=1}^{i-1} a_{k,i} a_{k,j}}{a_{i,i}}$$

[0012] alike -- following -- i= -- 2, 3, ..., j-1 -- ** ---izing ---like -- asking -- further -- aj and j -- [0013]

[Equation 4]

$$a_{j,j} = \sqrt{1 - \sum_{i=1}^{j-1} a_{i,j}^2}$$

[0014] what is searched for by carrying out -- ai, j, and j= -- 1, 2, ..., N+1 i= -- it is asking for 1, 2, ..., j.

[Translation done.]

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OPERATION

[Function] Changing R, then R by shadowing according to log normal distribution is known in the short section median of receiving level (for example, Moriji Kuwahara editorial supervision, a land mobile radiotelephone, the Institute of Electronics, Information and Communication Engineers issuance, Corona Publishing, Showa 60). It is here and is [0016].
[Equation 5]
$$X = \log(R) - \log(\bar{R}) \qquad (1)$$

[0017] If a change of variables is carried out, X will serve as a random variable according to an average of 0 normal distribution. However, [0018]
[External Character 1]
$\bar{R}$

[0019] It is the median of ** R.
[0020] By this invention, the change of variables of the variable showing shadowing is carried out like a formula 1, and it thinks as a normal-distribution variable. Then, in order to consider the case where the wave of N+1 wave of the wave of choice and N wave interference wave exists and to simulate shadowing to each wave, for the independent average of N+1 piece, distribution is the white normal random number of 1, X1, X2, ..., XN+1 at zero first. It generates. Furthermore, in order to take correlation of each shadowing into consideration, it is X1, X2, ..., XN+1. Linear combination is carried out and the an average of 0 distribution 1 is each the shadowing Y1 with correlation by which the change of variables was carried out, Y2, ..., YN+1. It considers asking. here -- the correlation coefficient of the i-th wave of N+1 wave, and the j-th wave -- rho -- i and j ** -- if it carries out -- rhoi and j =rho -- j and i (2)
It is [0021] when object nature is taken into consideration, since it ******.
[Equation 6]
$$\begin{pmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_N \\ Y_{N+1} \end{pmatrix} = \begin{pmatrix} a_{1,1}, & 0, & 0, & 0, & \cdots, & 0 \\ a_{1,2}, & a_{2,2}, & 0, & 0, & \cdots, & 0 \\ \vdots & \vdots & \ddots, & \ddots, & \ddots, & \vdots \\ a_{1,N}, & a_{2,N}, & a_{3,N} & \cdots & a_{N,N} & 0 \\ a_{1,N+1}, & a_{2,N+1}, & a_{3,N+1} & \cdots & a_{N,N+1} & a_{N+1,N+1} \end{pmatrix} \begin{pmatrix} X_1 \\ X_2 \\ \vdots \\ X_N \\ X_{N+1} \end{pmatrix} \qquad (3)$$

[0022] It is enough, if it comes out and the equation shown is taken into consideration. It sets to this equation and a problem is <Yi and Yj> =rhoi and j. (4)
<Yi and Yi> =1.0 (5)
They are ai and j so that the conditions to say may be fulfilled. It comes back to the ability to

set. Here, <Yi and Yj> are Yi. Yj An average is shown. ai and j If it can set, shadowing with the correlation by which the change of variables was carried out will be obtained. A formula (3) and a formula (5), and X1+X2, ... and XN+1 From a property, it is [0023].
[Equation 7]
$$\sum_{j=1}^{i} a_{i,j}^2 = 1.0 \quad (j \geq i, i, j = 1, 2, \cdots, N+1) \qquad (6)$$

[0024] **********. Moreover, a formula (3) and a formula (4), and X1, X2, ... and XN+1 From a property, it is [0025].
[Equation 8]
$$\rho_{i,j} = \sum_{k=1}^{i} a_{k,i} a_{k,j} \quad (i < j \; i = 1, 2, \cdots, N \; j = 2, 3, \cdots, N+1) \qquad (7)$$

[0026] **********. Here, it is a1 and 1 = 1.0 from a formula (6). for i= 1 (8)
[0027]
[Equation 9]
$$\sum_{j=1}^{i-1} a_{i,j}^2 + a_{i,i}^2 = 1.0 \quad for \; i > 1 \qquad (9)$$

[0028] **********. From a formula (9), it is [0029].
[Equation 10]
$$a_{i,i} = \sqrt{1.0 - \sum_{j=1}^{i-1} a_{i,j}^2} \qquad (10)$$

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$$\rho_{1,j} = \sum_{k=1}^{1} a_{k,1} a_{k,j} = a_{1,j} \quad for \; i = 1, j > i \qquad (11)$$
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$$a_{i,j} = \frac{\rho_{i,j} - \sum_{k=1}^{i-1} a_{k,i} a_{k,j}}{a_{i,i}} \qquad (13)$$

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EXAMPLE

[Example] The example which applied this invention when the interference wave of the wave of choice and two waves was taken into consideration is shown in drawing 1 . The random-number-generation circuit group from which 100 becomes the radical of shadowing to the interference wave of the wave of choice, and two waves in drawing, The memory group 101 remembers the long section median of shadowing [as opposed to / as opposed to / in a weighting composition circuit and 102 / a filter group / the interference wave of the wave of choice, and two waves in 103] to be, As for the memory group which memorizes distribution of shadowing [as opposed to / 104 / 105 / a change-of-variables circuit group and / as opposed to / in an adder group and 106 / a multiplier group / the interference wave of the wave of choice, and two waves in 107], and 108, an output terminal group and 109 are instant fluctuation phasing simulator groups. By the random-number-generation circuit group 100, the three normal random numbers with which each becomes independent are generated in the an average of 0 distribution 1 used as the radical of shadowing to the interference wave of the wave of choice, and two waves. These random-number groups are inputted into the weighting composition circuit 101, and the correlation defined beforehand is given.
[0040] When taking into consideration the interference wave of the wave of choice, and two waves, the weighting composition circuit 101 can be constituted like drawing 4 . As for an adder, and 410-414, for an input terminal, and 403-407, in drawing 4 , memory, and 415-417 are [400-402 / a multiplier and 408,409] output terminals. The random number used as the radical of shadowing of the wave of choice outputted from the random-number-generation circuit group 100, an interference wave 1, and an interference wave 2 is inputted from input terminals 400-402, respectively, and weighting composition is carried out as shown in drawing 4 . Here, it is rhoD-I1, rhoD-I2, and rhoI1-I2. It is the correlation coefficient which the wave of choice-interference wave 1, the wave of choice-interference wave 2, and the interference wave 1-interference wave 2 are made to produce and which was defined beforehand, and is rhoD-I1, rhoD-I2, and rhoI1-I2 in memory 410-413. It considers as a variable and is [0041].
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[0042] The value come out of and given is memorized. Weighting is carried out by memory 410-414, the adder 408,409, and multipliers 403-406, desired correlation is added, and the random-number group generated from the random-number-generation circuit group 100 is outputted,

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[0043] Generally, when taking into consideration N+1 of the wave of choice, and N wave interference wave wave, the part of the weighting composition circuit to the input random number of j and eye watch (j= 1, 2, ..., N+1) can be constituted like drawing 5 . For an input terminal group, 501-1 - 501- (j-1), and 502, as for an adder, and 504-1 - 504-j, in drawing 5 , a multiplier and 503 are [500-1 - 500-j / memory and 505] output terminals. When taking N+1 wave into consideration, a random number is generated from N+1 random-number-generation circuit, and the signal from 1, 2, ..., the j-th random-number-generation circuit is inputted from an input terminal 500-1 - 500-j to the j-th random number, respectively. j inputted random numbers are weighting factors a1 and j, a2 and j, ..., aj and j like drawing 5 . Weighting is carried out using the multiplier of j pieces. here -- a1, j, a2 and j, ..., aj and j the multiplier of j pieces -- the combination of the arbitration of each wave -- a cross correlation function rho -- i and j -- (-- i= -- 1, 2, ..., j j= -- the flow shown in drawing 3 if 1, 2, ..., N+1) is given -- following -- ** -- it can ask in-izing.
[0044] The output from the weighting composition circuit 101 obtained as mentioned above is the normal random number with correlation of the an average of 0 distribution 1. In order to give the suitable time variation to shadowing of each wave here, each output of the weighting composition circuit 101 is graduated by the filter group 102. Here, each transfer function Hj (omega) of the filter group 102 is |Hj |(omega)2 =1.0. (20)
****** is filled and distribution and an average of each random number are saved by using what does not produce direct current offset. In order to give distribution of desired shadowing according to the output of the filter group 102 While carrying out the multiplication of the distribution of shadowing to each wave memorized by the memory group 107 To the pan adding the long section median of each wave memorized by the memory group 103, by the change-of-variables circuit group 104, distribution and a median change multiplication and the added normal random number into a log-normal-distribution random number based on a formula (14), respectively, and shadowing which a desired cross-correlation produces is obtained. A more precise propagation environment can be simulated by inputting into the existing instant fluctuation phasing simulator group 109 (Rayleigh fading simulator) shadowing of each wave obtained as mentioned above, and giving the instant fluctuation based on given shadowing.
[0045] In addition, this invention can also be mounted using software. In this example Moreover, the weighting composition circuit 101, the filter group 102, a median adder unit (the memory group 103 and the adder group 105 which memorize the long section median of shadowing to the interference wave of the wave of choice, and two waves), Since all the distributed multiplication sections (the memory group 107 and the multiplier group 106 which memorize distribution of shadowing to the interference wave of the wave of choice and two waves) are linearity actuation, even if they replace and carry out sequence, they can acquire equivalent effectiveness.

[Translation done.]

* NOTICES *

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the schematic diagram showing the example which applied invention of the 1st of this application when the interference wave of the wave of choice and two waves was taken into consideration.
[Drawing 2] It is the schematic diagram showing a Prior art.
[Drawing 3] It is the flow chart which shows the flow which asks for the weighting factor of the weighting composition circuit 101.
[Drawing 4] It is the schematic diagram showing the example of the weighting composition circuit at the time of taking into consideration the interference wave of the wave of choice, and two waves.
[Drawing 5] It is the schematic diagram showing the weighting circuitry to the output of the j-th random-number-generation circuit at the time of generally taking N+1 wave into consideration.
[Description of Notations]
100 Random-Number-Generation Circuit Group Used as Radical of Shadowing to Interference Wave of Wave of Choice, and Two Waves
101 Weighting Composition Circuit
102 Filter Group
103 Memory Group Which Memorizes Long Section Median of Shadowing to Interference Wave of Wave of Choice, and Two Waves
104 Change-of-Variables Circuit Group
105 Adder Group
106 Multiplier Group
107 Memory Group Which Memorizes Distribution of Shadowing to Interference Wave of Wave of Choice, and Two Waves
108 Output Terminal Group
109 Instant Fluctuation Phasing Simulator Group
200 Memory Circuit Group Which Memorizes Shadowing Data Obtained in Measurement Experiment
201 Rayleigh Fading Simulator Group Which Simulates Instant Fluctuation Phasing
202 Output Terminal Group
400-402 Input terminal
403-407 Multiplier
408,409 Adder
410-414 Memory
415-417 Output terminal
500-1 - 500-j Input terminal group
501-1- 501, - (j-1), 502 Multiplier
503 Adder
504-1 - 504-j Memory
505 Output Terminal

[Translation done.]